Using automated camera imagery processing for surface transportation weather applications

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Outline

- Current camera surveillance
  - Usage
  - Deployments
- Weather extraction
  - Potential uses
  - MIT/LL Algorithm development
  - CLARUS research
- Future possibilities

Current Camera Usage

- **Traffic surveillance**
  - **Accidents/Incidents**
  - **Red light / Speed enforcement**
  - **Traffic flow**
- **Security**
  - **Premises monitoring**
  - **Intruder/Incident alerting**
  - **Homeland defense (terrorist threat surveillance)**
- **Weather/ General condition information**
  - **511 services**
  - **Web based displays for commuters**
  - **Scenic cameras (tourism)**

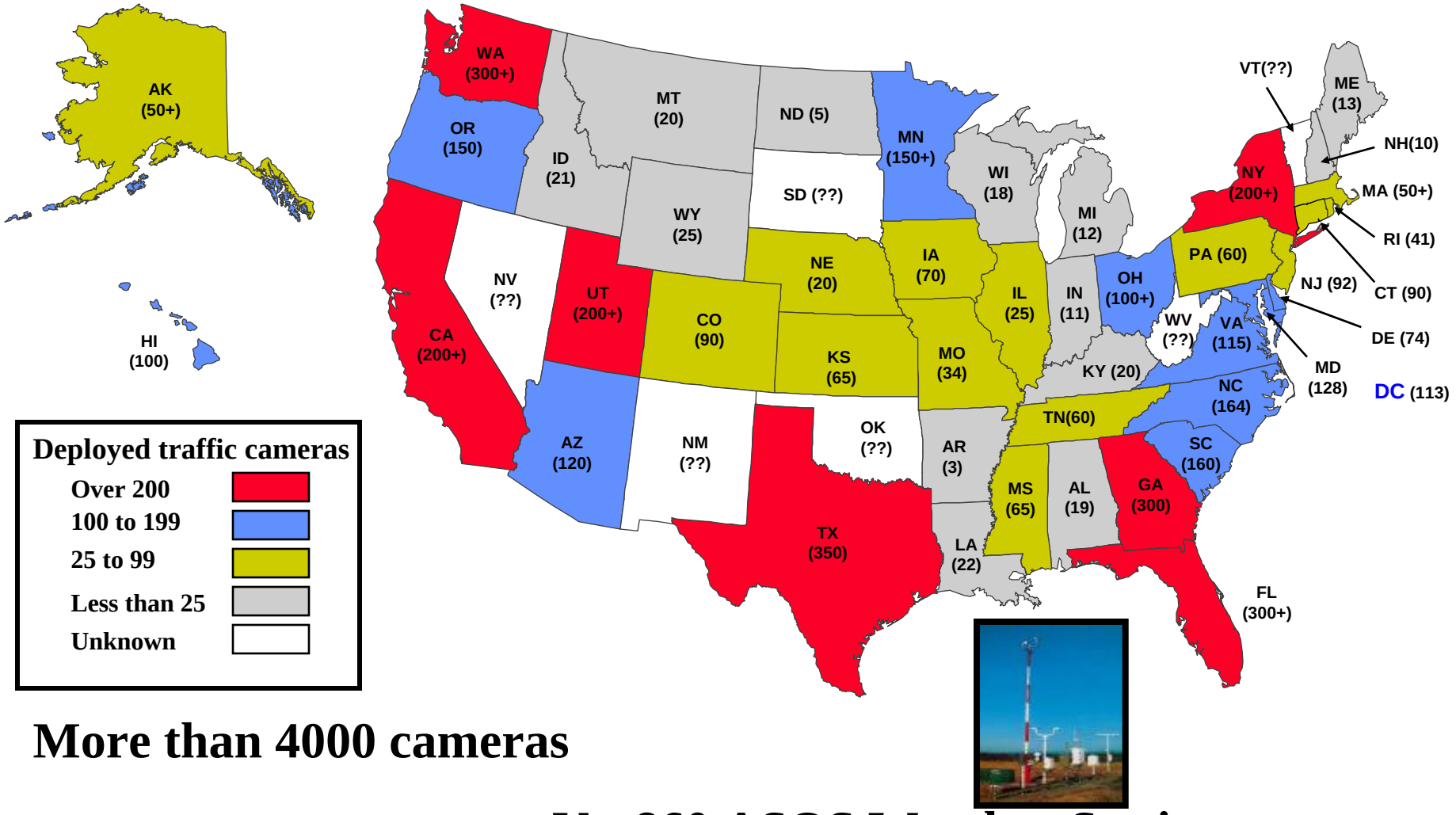
Example Camera Integration

Salt Lake City

Utah

150+ Cameras

State DOT Controlled Cameras (public survey)

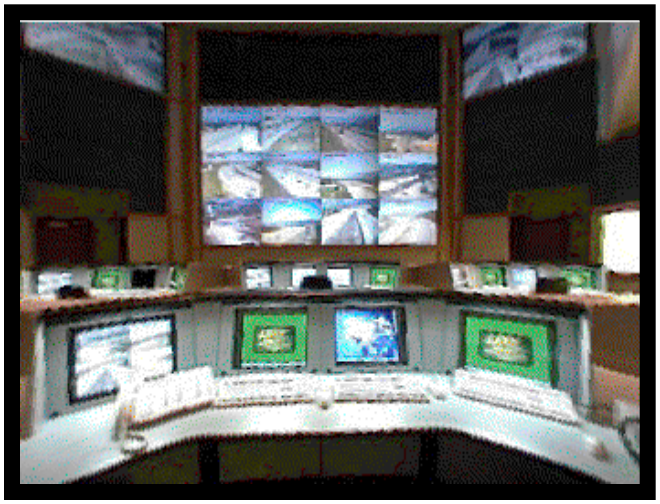


More than 4000 cameras

Vs. 860 ASOS Weather Stations

What's wrong with these pictures?

- Labor intensive
- Only a subset examined
- Focused on traffic incidents
- Details often lost



Real-time Traffic Cameras Rich Source of Information
- Need Automated Algorithms

Video camera observed weather variables

- **Automatically measure visibility and detect fog utilizing standard visible camera imagery**

Visibility: 1 km : No Fog

Roadway Conditions:
Partially Snow Covered

Precipitation: Moderate Snow

Visibility(km)
>10
>5
1-5
0.0-1.0

Visibility: 0.2 km : Heavy Fog : Thickening

Fog Description
Heavy
Moderate
Light

Roadway Conditions: Clear

Precipitation: None

MIT/LL Research: Guidelines & Assumptions

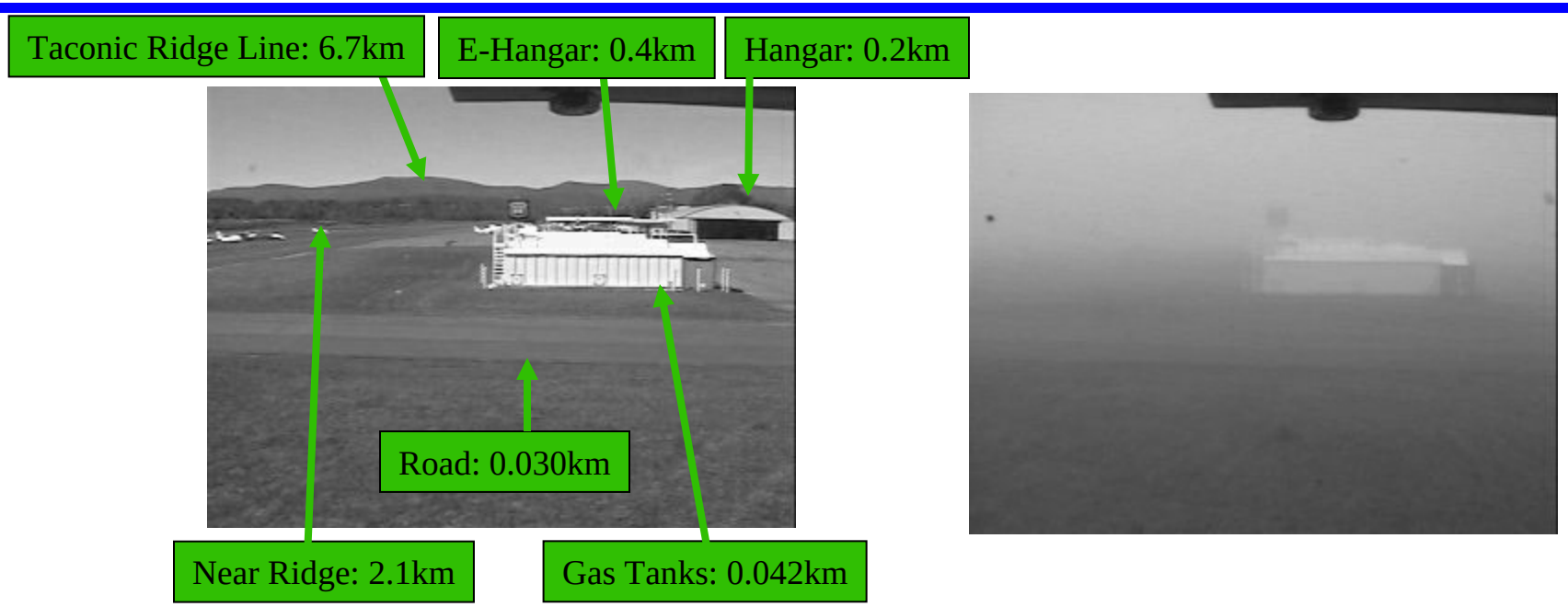
- **Keep sensor requirements simple**
  - Digital camera at known location
  - View must capture multiple ranges
  - Daylight imagery

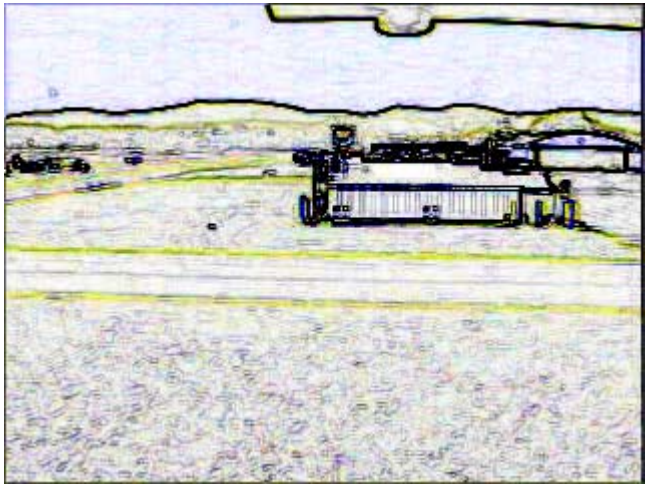
- **Require only limited image range survey**

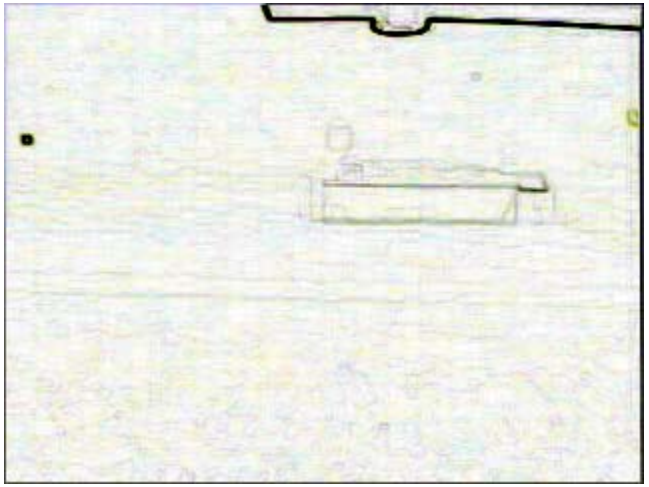
- **Focus on key ranges of visibility**
  - Visibility < 10km (and in particular < 1km)

Visibility(km)
>10
>5
1-5
0.0-1.0

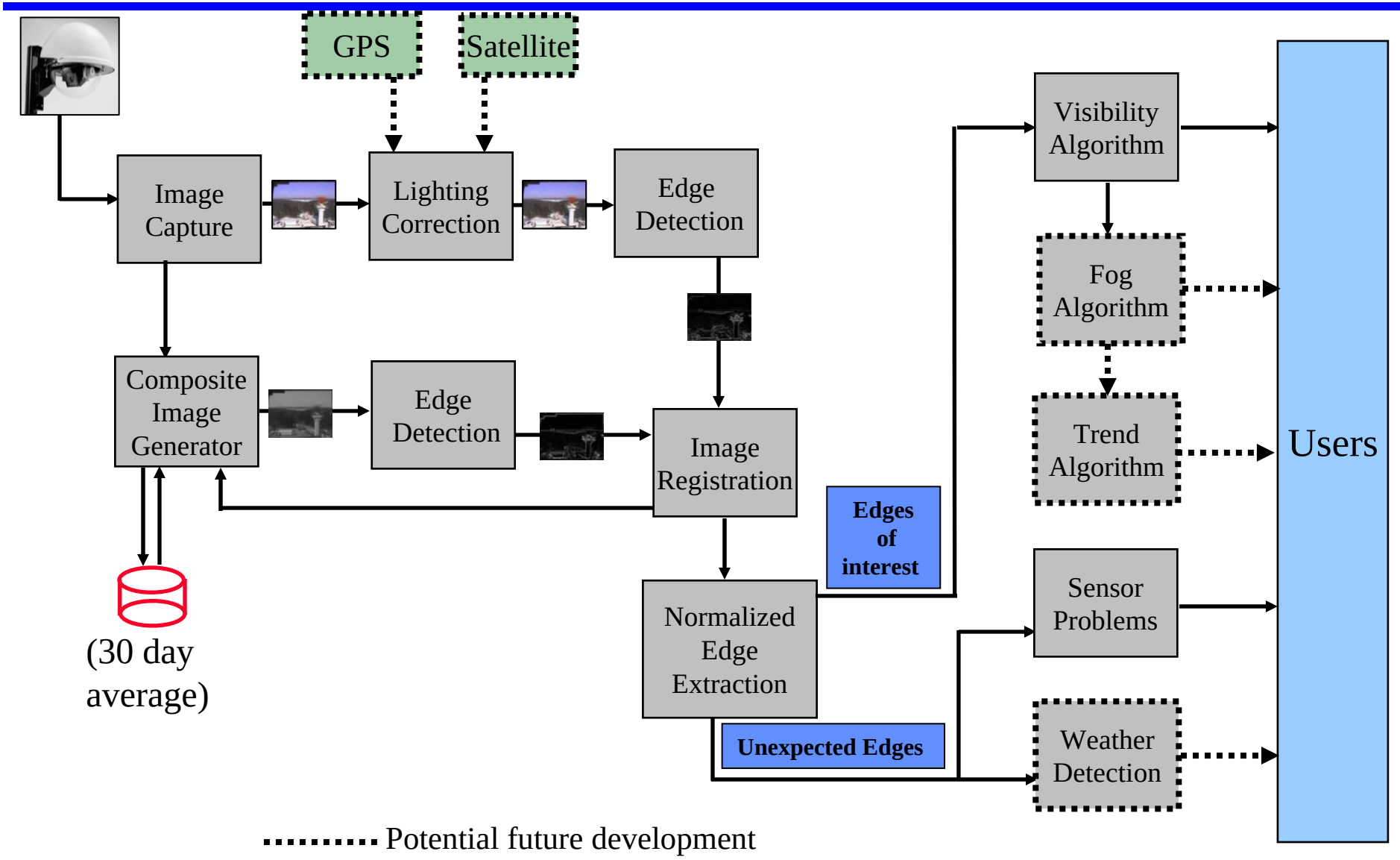
Utilize Edge Extraction as Basis



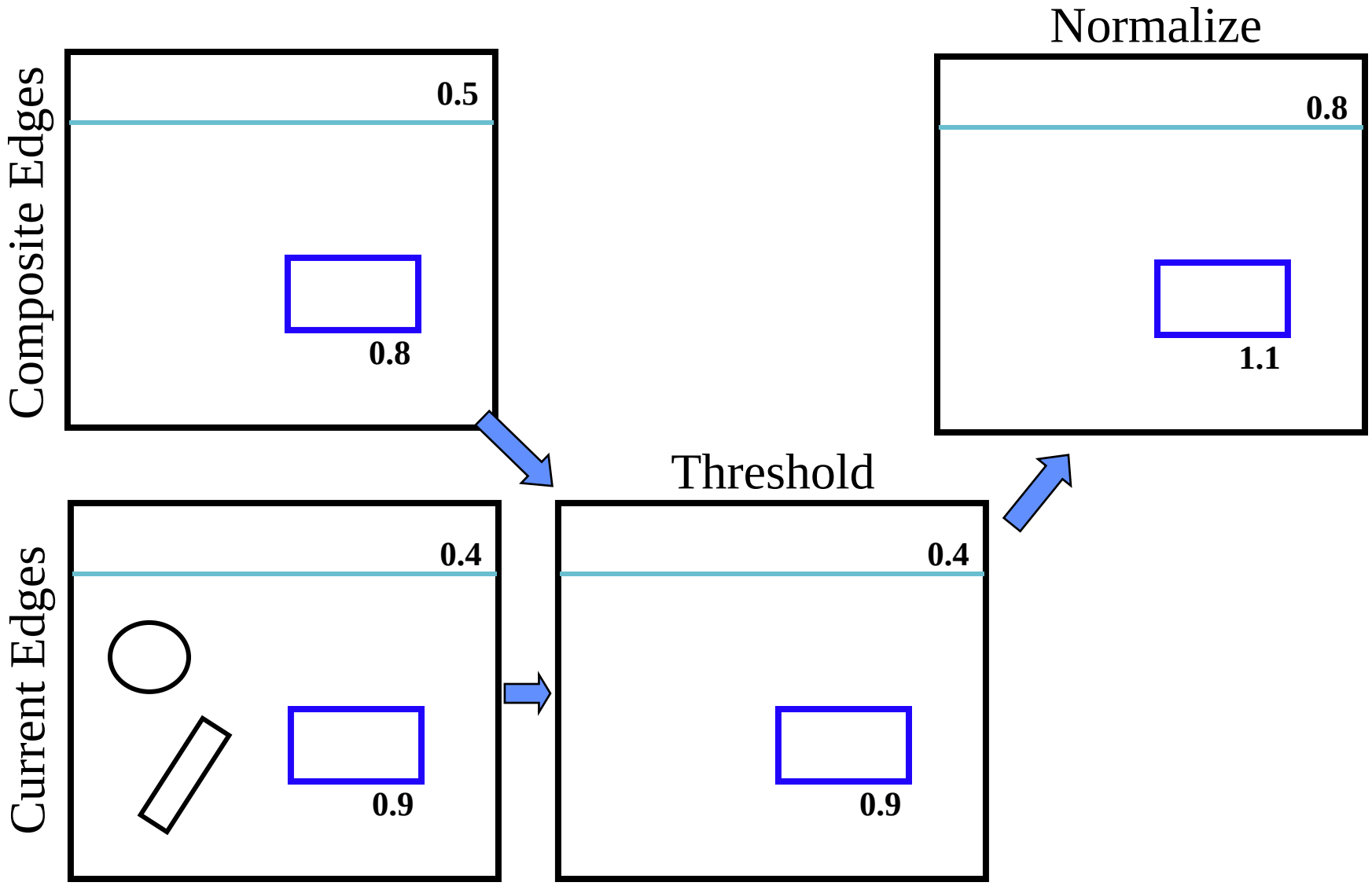




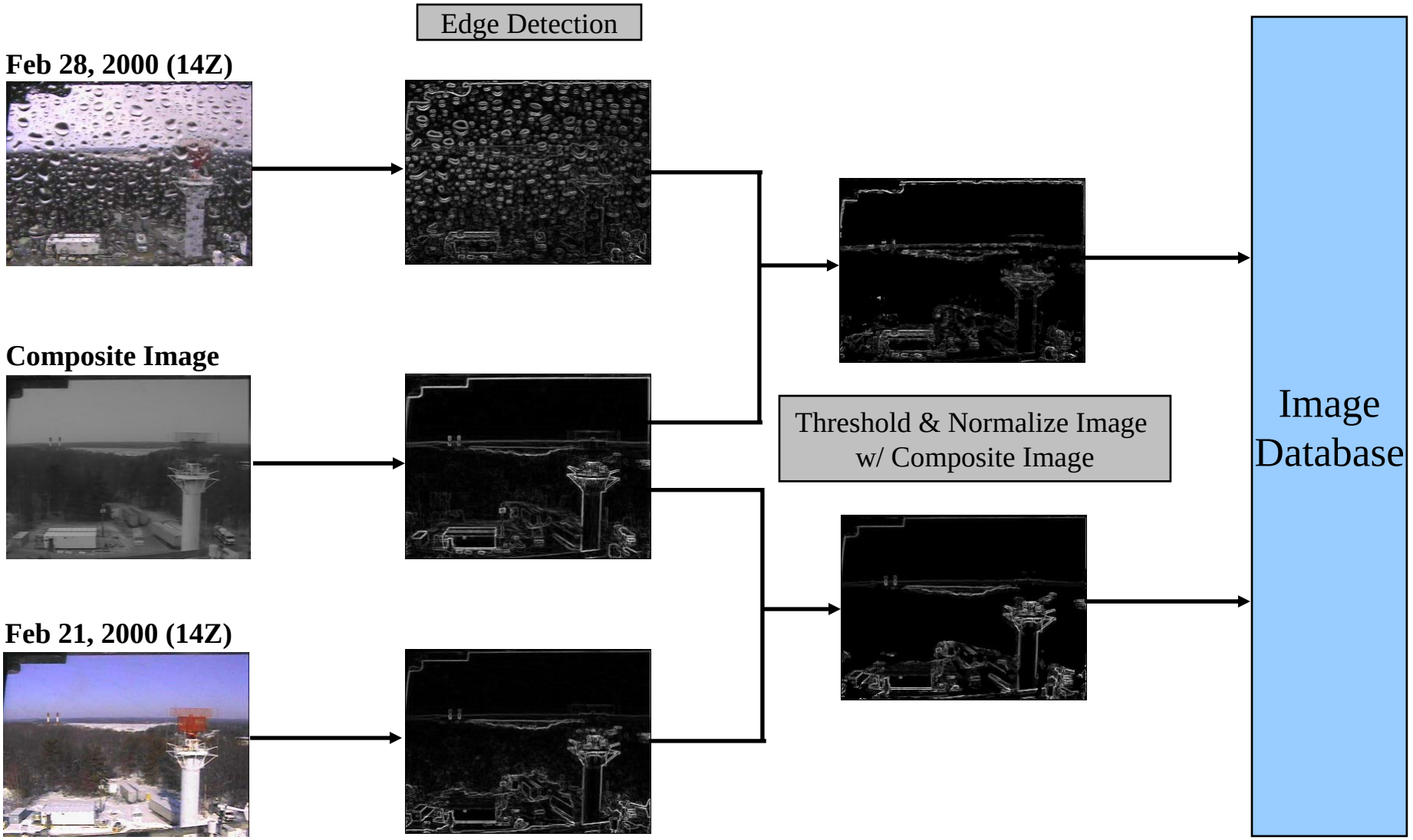
Algorithm Flow Chart



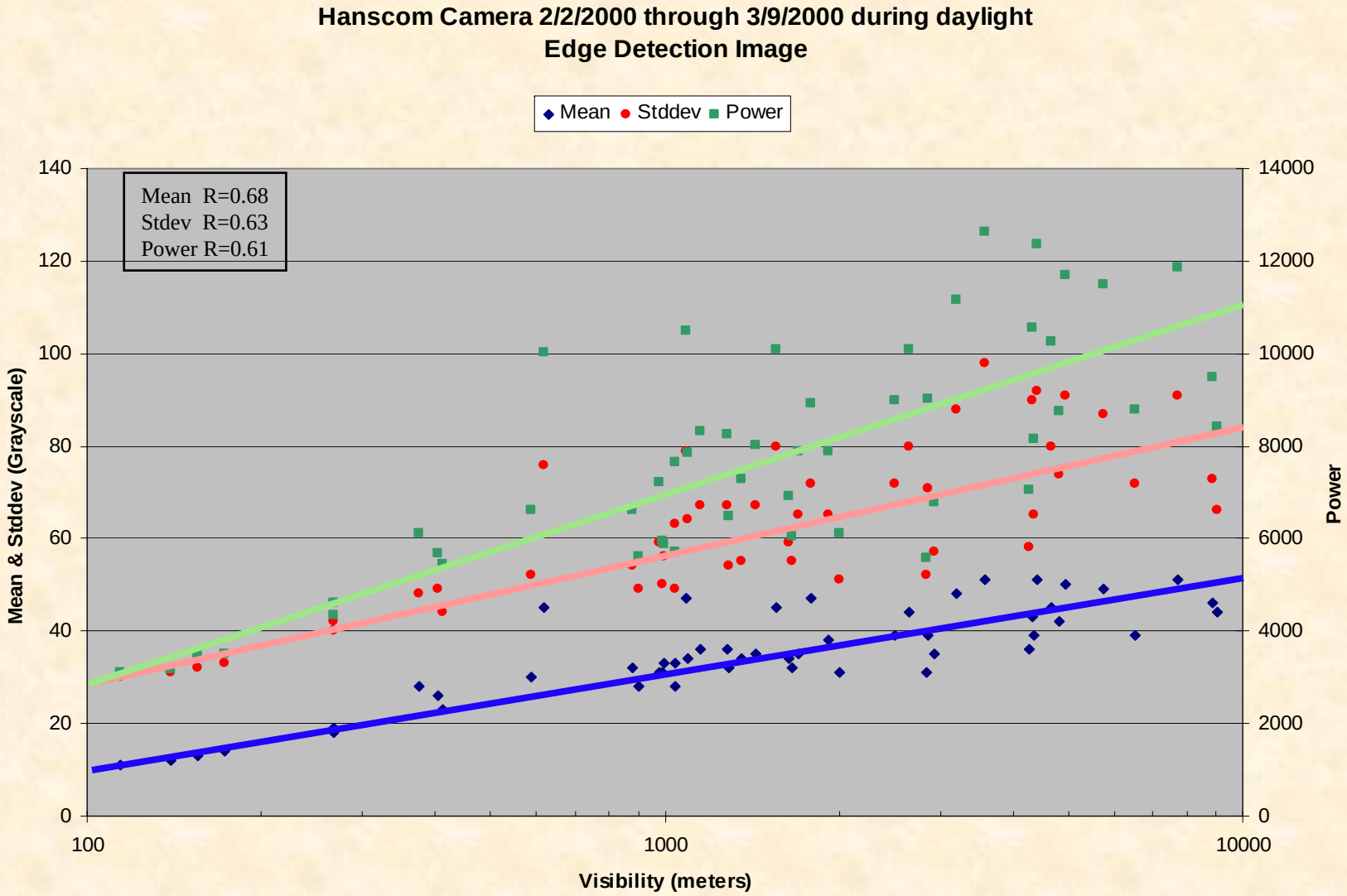
Threshold & Normalize



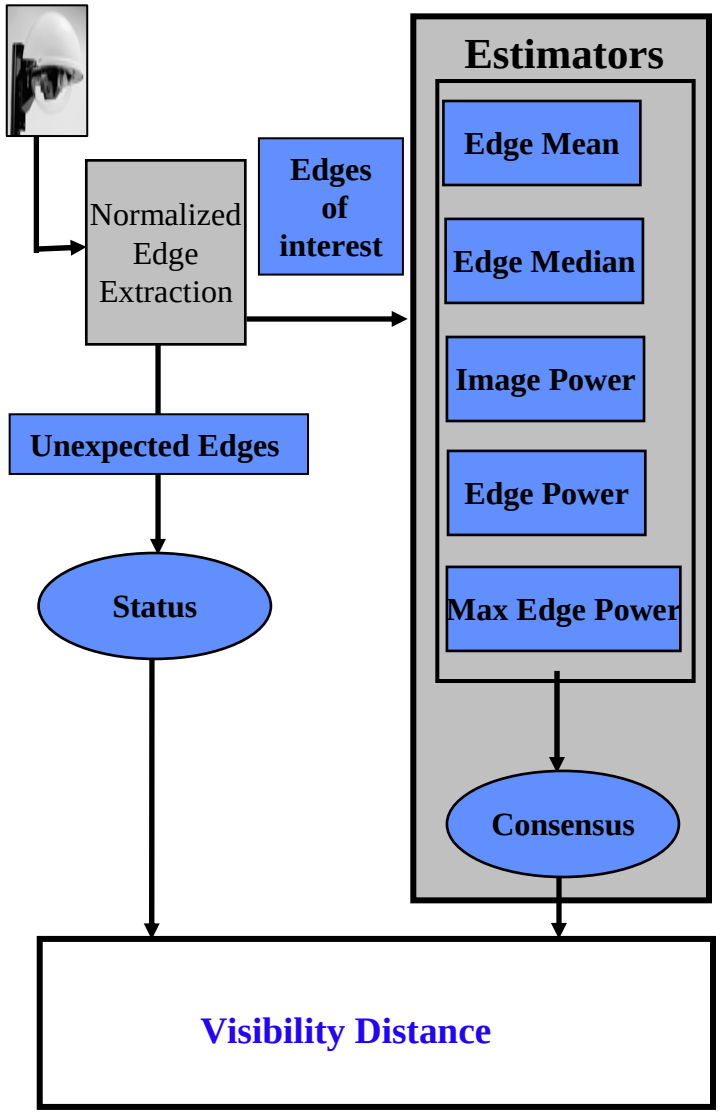
Data Quality Issues



Multiple Determination Techniques



Visibility Algorithm - Initial Assessment



Video Estimated Visibility (km)

ASOS Visibility (km)	<1	1-5	5-10	≥ 10
<1	28	2	0	0
1-5	1	24	11	6
5-10	0	10	64	32
≥ 10	0	46	174	663

Mt. Greylock, MA hourly daylight images 7/1-10/31/00 (estimators trained on same data set)

CLARUS research: Apply algorithm generically

- Investigate current standard practice for camera imagery
- Refine algorithm at MIT/LL using off-the-shelf cameras
- Connect to multiple DOT deployed cameras to test algorithm for determining general visibility
- Funding $250K for 1 year through 6/1/2006

02/11/2000 20Z (Vis 100 meters)

02/18/2000 20Z (Vis 1000 meters)

02/28/2000 17Z (Vis 10 miles)

CLARUS research: Cab-height visibility

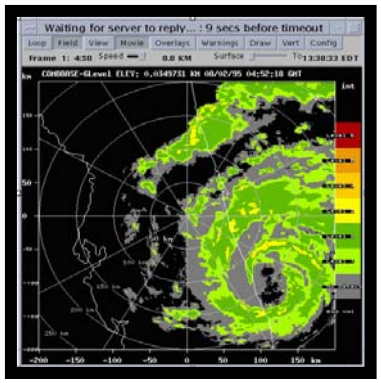
- **Utilize two-tiered MIT/LL camera system to determine feasibility of predicting cab-height visibility from elevated traffic cameras**

A “Vision” for Camera Usage

Image Database

Image	Attributes	Image	Attributes
	**Wx: Clear, distant clouds** **Road: Clear** **Traffic: Light** **Camera: OK** **Security: Normal**		**Wx: Unknown** **Road: Unknown** **Traffic: Unknown** **Camera: Unavailable** **Security: Cautious**
	**Wx: No precip** **Road: Clear, snow off-road** **Traffic: Hvy, slow, accident** **Camera: OK** **Security: Normal**		**Wx: Snow** **Road: Snow covered** **Traffic: Hvy, stopped, accident** **Camera: OK** **Security: Normal**

Camera Decision Support Applications



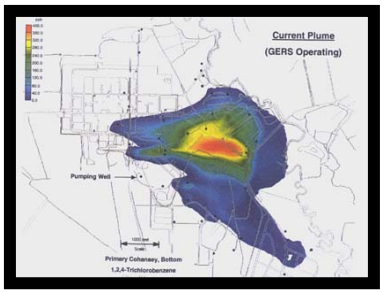
Hurricane Evacuation

- Route selection

Weather & Road Prediction Technology

Winter Maintenance

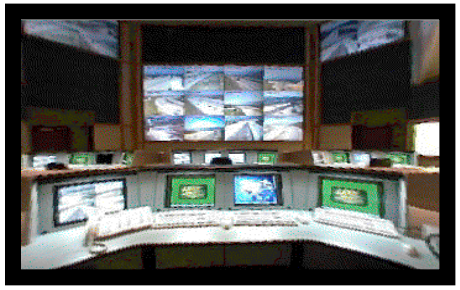
- Road condition feedback



Emergency Management

- Route selection

- Threat assessment



Traffic Management

- Signal timing

- Camera view selection

511 Travel

- Travel time feedback

- Viewable routes

Summary

- Camera deployments have expanded rapidly
- Automated techniques are needed to optimize usage
- Cameras provide valuable weather information
- MIT/LL under CLARUS is developing algorithms to extract weather variables from standard camera imagery
  - Estimated completion 6/1/2006
- Opportunities for further development